

What is claimed is:

<sup>2</sup>/<sub>1</sub>. A battery management system for a portable patient worn electronic energy delivery device for monitoring and administering therapy for a treatable heart condition, the battery management system comprising:

- a. a portable electronic device having a rechargeable battery means and a data storage/processor means; and
- b. a base station having receptacle means for receiving the portable electronic device, said receptacle means further comprising port means for operatively connecting the base station with the portable electronic device so as to transfer data there-between, power supply means for providing a current to said rechargeable battery means through said port means, computer means adapted to exchange information with said data storage means and maintenance means for providing an indication of the operation of the portable electronic device.

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3/<sub>2</sub>. The battery management system as recited in claim <sup>2</sup>/<sub>1</sub>, wherein said maintenance means comprises means for determining a charging condition of said rechargeable battery means, means for comparing the charging condition with at least one predetermined parameter stored in a data storage means operatively connected to said computer means, and means for inducing said power supply means to provide a charging current to said rechargeable battery means when the comparing means has determined the charging condition is below a predetermined level of the at least one predetermined parameter.

4/<sub>3</sub>. The battery management system as recited in claim <sup>2</sup>/<sub>1</sub>, wherein said portable electronic device comprises a monitor-defibrillator unit adapted to be worn by a patient for

delivering electrical therapy to the heart of the patient upon the occurrence of a treatable heart arrhythmia, and said data storage means includes means for storing patient physiological data.

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A. The battery management system as recited in claim 3, further comprising programming means and said base station comprises a programming interface, wherein said programming means permits an operator to input patient background data to said data storage means of the monitor-defibrillator unit.

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B. The battery management system as recited in claim 4, wherein said programming means further comprises means for retrieving said patient physiological data from said monitor-defibrillator and for transmitting said patient physiological data to a remote location.

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C. The battery management system as recited in claim 1, wherein said portable electronic device further comprises means for retrieving data from data storage means, and means for transmitting said data to a remote location.

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D. The battery management system as recited in claim 1, wherein said data storage means comprises means for storing manufacturing data for the portable electronic device, said manufacturing data including at least one of the following:

- a. device serial number;
- b. rechargeable battery means serial number;
- c. rechargeable battery means expiration date; and

d. a permissible number of rechargeable battery means recharges.

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The battery management system as recited in claim <sup>8</sup>7, wherein said computer

means further comprises a real time clock for providing an indication of actual date and time and means for comparing said actual date and time with said rechargeable battery means expiration date, and means for providing an alarm if said actual date and time exceeds said rechargeable battery means expiration date.

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The battery management system as recited in claim <sup>3</sup>2, wherein said base station

further comprises means for testing the operation of said rechargeable battery means, said testing means comprising means for discharging the rechargeable battery means to a predetermined starting level, means for recharging the battery to a predetermined charging level, means for performing a load test on said rechargeable battery means to determine integrity of said rechargeable battery means.

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The battery management system as recited in claim <sup>8</sup>7, wherein said computer

means further comprises counter means for counting the number of times said power supply means provides current to said rechargeable battery means, means for comparing said permissible number of rechargeable battery means recharges with the number of times counted by said counter means, and means for providing a second alarm if the number of times counted by said counter means is equal to said permissible number of rechargeable battery recharges.

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11. The battery management system as recited in claim ~~8~~<sup>9</sup>, wherein said base station further comprises a back-up power source operatively associated with said real time clock independent of said power supply means.

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12. The battery management system as recited in claim ~~1~~<sup>2</sup>, said base station further comprising display means operatively associated with said maintenance means for displaying information indicative of the operation of the portable electronic device.

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13. The battery management system as recited in claim ~~12~~<sup>13</sup>, wherein said display means comprises one or more of a character display panel and LED indicators for displaying the charging condition of said rechargeable battery means.

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14. A method of testing an operating characteristic of a portable patient worn electronic energy delivery device, said method comprising the steps of:

- a. providing a base station for receiving the portable electronic device, the base station having port means for transferring data between the base station and the portable electronic device;
- b. connecting the portable electronic device to said port means;
- c. transferring data from the portable electronic device to said base station;
- d. analyzing said data received from the portable electronic device; and
- e. providing an indication of the condition of the operating characteristic of the portable electronic device.

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The battery management system as recited in claim 1 wherein said personal electronic device further comprises:

a. data processing means for determining available device operating time before said rechargeable battery means requires recharging, said data processing means operatively associated with said data storage means;

b. said data storage means stores data corresponding to at least one of abnormally high current draw, normal current draw during an elapsed time period, device fault conditions and depletion of battery capacity during non-use, and said data processing means utilizes said data in determining said available device operating time;

c. patient display means operatively associated with said data processing means for displaying said available device operating time; and

d. alarm means associated with at least one of said data processing means and said patient display means, said alarm means notifying a patient of said available device operating time.

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The battery management system as recited in claim 2 wherein said personal electronic device further comprises:

a. voltage converter means for storing energy from said rechargeable battery means; and

b. control means operatively associated with said voltage converter means and said rechargeable battery means, said control means having:

i. means for determining an energy condition of said voltage converter, said energy condition including at least an insufficient energy condition wherein there is insufficient energy to both deliver a treatment to the patient and preserve operating data,

ii. means for determining a voltage condition of said rechargeable battery means, said voltage condition including at least an inadequate voltage condition wherein the battery capacity is inadequate for reliable operation of the device,

iii. means responsive to at least one of said inadequate voltage condition and said insufficient energy condition for one of operating said voltage converter means in a low current mode and terminating the operation of said voltage converter means, and

iv. discharge means responsive to said inadequate energy condition for discharging said voltage converter means;

and

c. notifying means operatively associated with said control means, said notifying means informing the patient whether the personal electronic device can provide treatment based on said converter energy condition and said voltage condition, and wherein said notifying means is at least one of a means for providing an alarm, a means for providing a voice message, and a personal electronic device display means.

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The battery management system as recited in claim 1 wherein said personal electronic device further comprises:

- a. control means operatively associated with said rechargeable battery means and said control means operating the personal electronic device in a low current mode when the device is not performing necessary system operating functions;
- b. said control means further having a means for determining a voltage condition of said rechargeable battery means, said voltage condition including at least an inadequate voltage condition wherein the battery capacity is inadequate for reliable operation of the device and wherein said control means refusing to power up the personal electronic device responsive to said inadequate voltage condition; and
- c. a digital to analog converter operatively associated with said control means and said control means can power down said analog to digital converter to conserve energy when not in use.

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The battery management system as recited in claim 1 wherein said personal electronic device further comprises:

- a. voltage converter means for storing energy from said rechargeable battery means;
- b. control means operatively associated with said voltage converter means and said rechargeable battery means and said control means having:
  - i. means for determining an energy condition of said voltage converter,
  - ii. means for determining a voltage condition of said rechargeable battery means, and

iii. means for performing a load test on said rechargeable battery means for testing high current capability of said rechargeable battery means;

and

c. an analog to digital converter operatively associated with said control means and said analog to digital converter for use in monitoring stored battery energy.

<sup>20</sup>  
~~19~~. The battery management system as recited in claim <sup>2</sup>~~1~~ wherein said data storage means further comprises data processing means for determining available device operating time before said rechargeable battery means requires recharging.

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~~20~~. The battery management system as recited in claim <sup>20</sup>~~19~~ further comprising portable electronic device display means operatively associated with said data processing means, said portable electronic device display means for displaying said available device operating time.

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~~21~~. The battery management system as recited in claim <sup>20</sup>~~19~~ wherein data corresponding to at least one of abnormally high current draw, normal current draw during an elapsed time period, device fault conditions, and depletion of battery capacity during non-use is stored by said data storage means, and wherein said means for determining said available device operating time uses said data.

<sup>23</sup>  
~~22~~. The battery management system as recited in claim <sup>20</sup>~~19~~ wherein said data processing means further comprises an analog to digital converter.

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The battery management system as recited in claim ~~22~~ wherein said analog to digital converter can be powered down to conserve power when not being used.

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The battery management system as recited in claim ~~22~~ wherein said portable electronic device further comprises:

- a. control means operatively associated with said rechargeable battery means; and
- b. voltage converter means for storing energy from said rechargeable battery means.

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The battery management system as recited in claim ~~24~~ wherein said control means comprises:

- a. means for determining a converter energy condition of said voltage converter, said converter energy condition including at least an insufficient energy condition wherein there is insufficient energy to both deliver a treatment to the patient and preserve operating data;
- b. means for determining a battery voltage condition of said rechargeable battery means, said battery voltage condition including at least an inadequate voltage condition wherein the battery capacity is inadequate for reliable operation of the device;
- c. means responsive to at least one of said inadequate voltage condition and said insufficient energy condition for one of operating said voltage converter means in a low current mode and terminating operation of said voltage converter means; and
- d. discharge means responsive to said insufficient energy condition for discharging said voltage converter means.

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~~26~~. The battery management system as recited in claim ~~25~~ further comprising

notifying means operatively associated with said control means for notifying the patient whether the personal electronic device can provide sufficient energy for treatment based on said converter energy condition and said battery voltage condition.

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~~27~~. The battery management system as recited in claim ~~26~~ wherein said means for

notifying is at least one of a means for providing an alarm, a means for providing a voice message, and said personal electronic device display means.

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~~28~~. The battery management system as recited in claim ~~27~~ wherein said control means

further comprises an analog to digital converter for monitoring stored battery energy.

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~~29~~. The battery management system as recited in claim ~~28~~ wherein said control means

further comprises means for performing a load test on said rechargeable battery means for testing high current capability of said rechargeable battery means.

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